INTESTINAL PARASITES IN CHILDREN*

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Despite the emphasis which for many years has been laid upon laboratory methods in diagnosis, and the extent to which examinations are made of blood, urine and feces in hospital practice at least, our knowledge of the number and variety of intestinal parasites in children is very imperfect. The information contained in standard texts is often such as to support the view that these organisms are of little importance. This situation is fairly well pictured by a quotation from a much used work on children's diseases:

"The worms which are found in the intestines of infants and children are the same as those which occur in older patients. The only ones which are common and important enough to speak of are the Oxyuris vermicularis or pin worm, Ascaris lumbricoides or round worm, Taenia solium (pork tapeworm), and Taenia mediocanellata (tapeworms)."

Now, as a matter of fact, there are only three errors in this statement concerning the parasites of children: (1) They are not characteristically "the same as those which occur in older patients." (2) Those mentioned are not "the only ones which are common and important enough to mention." (3) Two of the four are neither common nor relatively important.

The questions to be considered and answered as far as possible are: (1) What forms do occur in the United States of America? (2) How frequent are they? (3) What is their relative significance? (4) How does infection occur?

In 1906 Stiles and Garrison examined feces from 123 children under fifteen years of age and found infection with intestinal worms in 21.14 per cent. Trichuris was present in 13 per cent., Oxyuris in 1.63 per cent., Ascaris lumbricoides in 0.81 per cent., and Hymenolepis nana in 4.88 per cent.

In 1910 Schloss published a careful study of 310 children between two and twelve years of age. Thirty of these were selected cases, but in a second group 280 were taken consecutively and included all of the given ages in the families treated. Of this group 28.57 per cent. were infected. Trichuris occurred in 11 per cent., Oxyuris in 8.2 per cent., Hymenolepis in 7.1 per cent., Ascaris in 2.1 per cent., and Taenia saginata in 1.8 per cent. of the cases.

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Within the past year, in a Southern city, in an examination that included 1,287 school children, from six to eighteen years of age, 36.73 per cent. of the white children and 49.12 per cent. of the negro children were found by Stiles to be infected with intestinal parasites. The infection with Endamoeba was 8.76 per cent. of white and 11.93 per cent in colored children. For Lamblia the figures were 12.75 and 6.46 per cent.; for Trichomonas, 0.64 per cent.; for Ascaris, 7.47 and 27.98 per cent.; for Oxyuris, 0.39 per cent.; for Trichuris, 1.28 and 11.54 per cent.; for Hymenolepis, 0.26 and 0.19 per cent., and for Necator, 10.69 and 3.33 per cent. respectively.

These records are drawn together for easy comparison in the following table. Separate numbers indicate percentage of infections; others show ratio in cases under examination:

	Stiles and Garrison	Schloss	Stiles in X white	Stiles in X colored
Trichuris	13 =1:8	11 =1:9	1.28=	11.54=
Ascaris lumbricoides	0.8 =1:125	2.1 =1:48	7.5 =1:13	28 =1:4
Oxyuris vermicularis	.....	8.2 =1:12	0.39=	3.3 =1:30
Necator	.....	.....	10.7 = .	0.19=1:500
Hymenolepis nana	5 =1:20	7.1 =1:14	0.26=1:400	.....
Taenia saginata	.....	1.8 =1:55	.....	.....
Endamoeba	.....	.....	8.8 =	11.9 =
Lamblia	.....	.....	12.75=	6.5 =
Trichomonas	.....	.....	0.64=	.....
Infected	21.1 =1:5	28.57=2:7	36.73=2:5	49.12=1:2

These figures seem high, in fact are higher, than would have been expected on the basis of European records. However, Oxyuris constitutes a marked exception to this statement, as it occurs in 30 per cent. of all European examinations (Kiel, Helsingfors, Munich), where it is thus eighty times as common as in this series of examinations. Part of the excess which the table shows may be due to some local condition favoring infection or spread of parasitic forms; another part is certainly due to the thorough character of the investigations in this country. They certainly indicate that intestinal parasites are more common than has been supposed, and hence constitute a danger even greater than has been recognized. These records are not extensive enough to form a basis in some instances for safe generalizations, but where the numbers are large they show interest-

ing relations to such things as geographic locations; for example, the hookworm ratio of 1:10, even in the city in the South, and not once found in 500 cases from Northern cities; to racial susceptibility, as in the three times greater frequence of hookworm in white children than in negroes; to manner of life, hygienic surroundings, etc.

Probably the most important fact for the present discussion is that no group shows a frequence of less than one case infected in every five. Note further that the earlier records took no notice of intestinal protozoa, and if the lowest probable estimate be placed upon these then the earlier records become two infected children in five examinations, or more; this agrees substantially with the record of the most favored group in the last examination quoted. Finally, let me direct especial attention to the fact that of the two tapeworms regarded generally as standard human parasites, one does not occur at all and the other only in one locality with a frequence of 1.8 per cent. Of the two round worms mentioned in the quotation, Oxyuris does not appear in two out of four groups and in only 0.4 per cent., or in 1:250 cases, in one other; in New York City among the class investigated it occurred once in 12 cases. The other round worm Ascaris appears in all four groups with a frequence of 0.8, 2.1, 7.5 and 28 per cent. or 1:125, 1:48, 1:13 and 1:4.

There are nine types of intestinal parasites recorded from children in these investigations and those omitted from the list cited are more widely distributed and more general in their occurrence as well as more frequent than those named. This analysis of the evidence presented shows clearly that two general conclusions concerning parasites in children are safe: (1) They are more frequent than commonly stated; (2) there are more varieties than usually listed.

Among the Trematodes or flukes there are none in this country which constitute a menace to the child. In fact, not a single species has yet been reported in a way to show clearly that it is endemic in the human host here; and the species which have been introduced from other countries in the various cases on record are known only from the adult and do not appear likely to be of especial significance to the immature. This would not hold good of the blood-fluke so common in Africa and Asia, and so sinister in its attacks on man. Fortunately its establishment on this continent appears unlikely for biologic reasons.

Among the Cestodes or tapeworms there are three species conspicuous for their size and long known by virtue of this and their abundance in certain regions. These are the pork tapeworm, Tenia solium, the beef tapeworm, Tenia saginata, and the fish tapeworm, Dibothriocephalus latus. As a matter of fact, all of these have been reported from hosts of all ages, even from suckling infants. But such cases are great rarities among many thousands of records. No one of them is as likely to be parasitic in a child as in an adult and both the fish tapeworm and the pork tapeworms are so rare on this continent that the discovery of a case ranks among the most unexpected of occurrences. They are accordingly not forms which demand the especial attention of the pediatrist and if ever present are so easily recognized that the case will present no especial difficulty in diagnosis. But this cannot be said of certain other cestodes.

Of the approximate thirty varieties of cestodes recorded from the human host, four are said to occur chiefly in children. These are all small forms and the knowledge of their occurrence is of recent acquisition. They are all forms to which the attention of students of children's diseases should be carefully directed, even though one of them has not been recorded outside of the sub-tropical zone. Their insignificant size renders them easily overlooked and present information is certainly inadequate to show their true range or frequence. In fact one of them, not even mentioned in many standard works, is in the opinion of investigators the most abundant North American tapeworm. These four important forms are the following:

Davainea madagascariensis has been reported only from tropical regions and the total number of cases on record is small. Of nine cases, two only are in adults. The normal host is probably not man and the intermediate host has been conjectured to be Periplaneta orientalis, the Eastern cockroach. The introduction of this parasite into the human intestine is due to gross carelessness or indifferent hygienic surroundings.

Dipylidium caninum is a normal parasite of dog and cat and is extremely abundant in those hosts. About 100 cases in man are on record. Most of these concern children, even of very immature age. Thirty-four per cent. of cases are in sucklings of five weeks to six months; 42 per cent. in infants of seven months to three years; 10 per cent. in children of four to eight years, and only 13.5 per cent. in those over eight years of age. The

bladderworm stage of this species is passed in the flea and the dog or cat infects itself by swallowing infected fleas. Children of tender years are infected by chance through too intimate contact with pet animals. Such contact is most frequent in the earliest years of a child's life, and small dogs chosen as pets for children are the types most generally subject to this parasite.

Two species of Hyemenolepis have been recognized in recent years as frequent parasites of man. These are Hymenolepis nana and Hymenolepis diminuta. The second is a common parasite of the rat, and the first, in the opinion of Grassi, is also. Unfortunately in neither species has the life-history been worked out and we are forced to base our conception of the source of infection in man on conjecture. One species is said to be transmitted directly to man through the ingestion by accident of the eggs or proglottids from another host. The other species is believed to pass through an intermediate host, some insect in which the bladderworm stage develops. The contamination of food or drinking water would suffice to carry that insect with the bladderworm into the human intestine. In either case, infection is due to that disregard of hygienic conditions which characterizes young children and those of defective mentality; and these are in fact the classes most largely infected by these parasites.

The Nematodes or roundworms furnish more parasites to the human species and consequently more to children than either of the groups mentioned before. Of Ascaris lumbricoides, the stomach worm, Oxyuris vermicularis, the pinworm, and Trichuris trichiura, the whipworm, so much has been said elsewhere that the mere mention is enough for the purposes of this discussion. They are important, they are generally easily recognized, and the treatment of such cases is well understood.

I may also pass unnoticed a number of rare species and of forms that have not yet been reported in our territory, except as imported in some immigrant from the infected area or traveller returning from it. Such species may become significant later, but are outside the limits of this discussion. There are left several species of Nematodes which call for especial consideration here.

No extended reference is needed to justify the mention of hookworm disease in this discussion. Its wide prevalence and serious effects are sufficiently known and probably everyone is familiar with the fact that it is conspicuously a disease of the young. In one record of 1,470 cases, 58.5 per cent. are listed as

under sixteen years of age and only 18.5 per cent. over twenty. Most of you are familiar with pictures showing the way in which the presence of this parasite reduces the vitality of the child and you doubtless are also aware that the effect on the growing organism may be produced by a small number of parasites. On the other hand, it is self-evident on a study of the life-history of the hookworm and the method of infection that children are much more likely to become infected than are adults in all save a few special occupations. This again is a parasitic disease to which the child is more liable than the adult and from which the effects are also more serious in the immature host.

It is important to emphasize further that this is a disease primarily of early life, although the statistics are inadequate to show clearly just how early in life it is acquired. The figures given by the Porto Rico Commission show that in a total of 278,000 cases treated up to 1911 over 11 per cent. were under ten years of age, and about 20 per cent. between ten and fourteen years, which is the five-year period embracing the greatest number of cases. Less extensive statistics from our Southern states show much the same relative frequence of cases in different age groups. One must bear in mind that the cases examined at ages in the ten to fourteen-year group were apparently infected first at five years or earlier. The data are not such as to furnish clear evidence on the exact age the infection is acquired.

Within very recent years, evidence has been secured to show that organisms almost unknown to pathology before, viz., the Protozoa, play an important rôle as parasites of the human intestine. These organisms are minute and delicate, hence difficult to obtain and to study. Special methods for their observation and culture are only just being worked out. One notes marked differences of opinion, even among investigators, as to the number of species of such organisms and as to their pathologic significance. But every year adds to the certainty of the conclusion that they are frequent and of serious import in human pathology. This is unquestionably one of the most fertile fields for research at the present time.

These organisms are both amoeboid and flagellate. No doubt there are many species and varieties. For the purposes of this discussion they may be treated as a group and some facts elucidated by recent studies be taken as representative of their special significance to students of children's diseases.

Stiles has called attention to the fact that the presence of certain protozoa, viz., Entamoeba coli, Lamblia, and Trichomonas, in the human intestine demonstrate that the host has ingested contaminated material. These organisms leave the body only in feces (or urine) and enter it only in spore form through the mouth. They have no free motile stage. For the adult, the presence of such parasites is evidently due in the large majority of cases to the ingestion of food or drink which has been contaminated by fecal material; and usually drinking water or uncooked vegetables are held responsible, as they can most easily act as mechanical carriers and are readily contaminated by sewage. But Stiles is convinced that in the region where he has been working the fly is a more frequent agent in the transmission. Breeding as these insects do in large numbers in surface privies of rural communities or of towns where such privies are permitted, the flies move directly from the source of contamination to the kitchens of the neighborhood and deposit the dirt and spores on food, dishes and other articles from which the transfer to the human mouth is immediate and natural. When 293 flies were caught in one flytrap in a surface privy and 1,742 flies in another flytrap in a kitchen only forty feet away, and when flies were seen passing to and fro between these places, carrying and depositing particles of lime, etc., the actual transfer of spores could hardly be doubted. Though extremely difficult to detect because of their minute size, the cysts being only seven to fifteen microns in length, some of the spores were actually detected in sterilized water used to wash flies that had visited contaminated material. In this particular community, the drinking water is sand filtered and can hardly contribute to the infection, which averages 23 per cent. in the 187 cases examined. The infection was 30 per cent. in those houses with a surface privy and dropped to 20 per cent. in houses having a sewage connection and no privy. Age statistics are not given, but the author notes that these Protozoa are exceedingly common in children, and an infection of 50 to 100 per cent. was not unusual in these families.

It may well be that some of the children acquired the parasites through the use of soiled hands, or by sucking toys, sticks, fruits, and other articles on which the spores had been deposited by flies. The disregard of hygienic precautions manifested by children generally no doubt does have its influence here and a census of adults would likely yield a lower percentage of

infection than that cited above. But, however, directly or indirectly acquired, the parasites are there, and command our attention here as dangers threatening the child.

Occasional clinical records emphasize this conclusion. Thus, for instance, epidemics of Lamblia in orphans' homes and other institutions for children furnish further evidence of the part the Protozoa play in children's diseases. In this as in other cases it is clear that the increase noted is due not to new diseases, but to more perfect knowledge accompanying newer methods of investigation.

The data just presented emphasize the importance of frequent fecal examinations. The presence of the smaller intestinal worms will often be unsuspected until the microscope shows up their characteristic ova. The Protozoa are demonstrable only by microscopic examinations. Even a little experience is adequate to distinguish the various types and thereafter a diagnosis is rapid and accurate. I should not leave this topic without a brief mention, at least of the pitfalls in the path of the diagnostician in the form of foreign materials usually of plant origin that are too easily diagnosed as worms. The most common in the feces of the child are pulp vesicles from the orange that simulate closely some sort of a fluke and the partly digested fiber of the banana, that are strikingly like a mass of small tapeworms. The latter have been discovered and described in this country at regular intervals since 1883, when Dr. William Osler first suggested their true nature.

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